This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problems Mailbox.

THIS PAGE BLANK (USPTO)

PATENT SPECIFICATION

(11) 121789

1217892

DRAWINGS ATTACHED

(21) Application No. 12538/68 (22) Filed 14 March 1968
(31) Convention Application No. 623 369 (32) Filed 15 March 1967 in
(33) United States of America (US)
(45) Complete Specification published 31 Dec. 1970
(51) International Classification A 62 b 18/02
(52) Index at acceptance A5T 503

THE PATENT OFFICE LONDON

(54) FACE MASK

PATENTS ACT 1949

SPECIFICATION NO 1217892

The following amendments were allowed under Section 29 on 20 September 1973:-

Page 4, line 96, *for* 0.1 *read* 0.01

THE PATENT OFFICE
31 October 1973

R 72060/23

standard for decades and which are in wide usage even today are composed of layers of gauze covering the nose and mouth. Even though the bacteria filtration efficiency of such masks is quite low initially and becomes even lower after a very short wear period, these masks have been widely used because they are easy to breathe through. Substitute material such as foamed rubbers, or woven webs formed from conventional synthetic organic fibers, have also only provided low bacteria filtration efficiency. Substitute materials incorporating small diameter inorganic fibers, for example, asbestos or glass, while providing good breathing and filtering characteristics, tend to present health hazards due to the possibility of inhalation of small inorganic particles. The use of very fine organic fibers has not been found practical prior to the present invention because webs made therefrom tended to be difficultly handleable and uncomfortable due to fuzziness of the material; or if made more coherent by heat and pressure tended to present too high a resistance to breathing.

This invention provides a face mask having a body portion adapted to cover the nose and mouth and means for securing said body portion of the nose and mouth, the body portion comprising a face contacting web comprising:

a non-woven, porous, self-sustaining flexible, fibrous matting having an exposed smooth, fuzz-free surface, and

The fibers in the filtering layer enable high small-particle filtering efficiency and yet have enough void volume to enable easy breathing or low resistance to air flow. The face contacting layer is substantially moisture-resistant due to the use of a thermoplastic material and will usually be tear-resistant. By being moisture-resistant, i.e. non-absorbent, the face contacting layer allows moisture and other small particles to pass therethrough without becoming wet to the touch, even after prolonged wear.

Masks of this invention are normally free of objectionable odors and in finished form are thus preferably substantially free of solvents or odor causing adhesives. Due to the nature of the preferred synthetic organic polymeric materials, the masks of this invention are resistant to deterioration from the moisture normally present in exhaled air. For use in surgery, it is preferred that the face mask material be dimensionally stable under ambient conditions, in addition to being relatively moisture-insensitive and odor-free.

If desired the face mask may include a non-woven fibrous web, the filtering web being contained between the surface opposite the exposed of said face contacting web and one surface of said retaining fabric layer.

The various layers of the masks are preferably held together only around the edges, but could also be fastened together at other points if desired. The mask is provided with,

PATENT SPECIFICATION

(11) 1217892

DRAWINGS ATTACHED

(21) Application No. 12538/68 (22) Filed 14 March 1968
(31) Convention Application No. 623 369 (32) Filed 15 March 1967 in
(33) United States of America (US)
(45) Complete Specification published 31 Dec. 1970
(51) International Classification A 62 b 18/02
(52) Index at acceptance A5T 503

1217892

(54) FACE MASK

(71) We, MINNESOTA MINING AND MANUFACTURING COMPANY, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 2501 Hudson Road, Saint Paul, Minnesota 55101, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be described in and by the following statement:—

This invention relates to face masks having high and prolonged filtering efficiency, especially suitable for use as surgical masks.

The surgical face masks which have been standard for decades and which are in wide usage even today are composed of layers of gauze covering the nose and mouth. Even though the bacteria filtration efficiency of such masks is quite low initially and becomes even lower after a very short wear period, these masks have been widely used because they are easy to breathe through. Substitute material such as foamed rubbers, or woven webs formed from conventional synthetic organic fibers, have also only provided low bacteria filtration efficiency. Substitute materials incorporating small diameter inorganic fibers, for example, asbestos or glass, while providing good breathing and filtering characteristics, tend to present health hazards due to the possibility of inhalation of small inorganic particles. The use of very fine organic fibers has not been found practical prior to the present invention because webs made therefrom tended to be difficultly handleable and uncomfortable due to fuzziness of the material; or if made more coherent by heat and pressure tended to present too high a resistance to breathing.

This invention provides a face mask having a body portion adapted to cover the nose and mouth and means for securing said body portion of the nose and mouth, the body portion comprising a face contacting web comprising:

a non-woven, porous, self-sustaining flexible, fibrous matting having an exposed smooth, fuzz-free surface, and

a porous, non-woven filtering web consisting substantially of thermoplastic organic fibers, said fibers being uniformly distributed through said filtering web and having diameters averaging less than 6 microns.

The face masks of this invention have high and prolonged filtering efficiency and they can be manufactured sufficiently economically to be disposable after a single use. The masks combine high filtering efficiency with wearing and breathing comfort, avoidance of fuzziness or other skin irritating properties, and the avoidance of the hazard of inhaling irritating particles.

The fibers in the filtering layer enable high small-particle filtering efficiency and yet have enough void volume to enable easy breathing or low resistance to air flow. The face contacting layer is substantially moisture-resistant due to the use of a thermoplastic material and will usually be tear-resistant. By being moisture-resistant, i.e. non-absorbent, the face contacting layer allows moisture and other small particles to pass therethrough without becoming wet to the touch, even after prolonged wear.

Masks of this invention are normally free of objectionable odors and in finished form are thus preferably substantially free of solvents or odor causing adhesives. Due to the nature of the preferred synthetic organic polymeric materials, the masks of this invention are resistant to deterioration from the moisture normally present in exhaled air. For use in surgery, it is preferred that the face mask material be dimensionally stable under ambient conditions, in addition to being relatively moisture-insensitive and odor-free.

If desired the face mask may include a non-woven fibrous web, the filtering web being contained between the surface opposite the exposed of said face contacting web and one surface of said retaining fabric layer.

The various layers of the masks are preferably held together only around the edges, but could also be fastened together at other points if desired. The mask is provided with,

for example, tie strings or elastic to hold the filtering portion of the mask over the user's nose and mouth and is preferably provided with a strip of soft deformable metal or the like along the edge of the mask designed to cover the user's nose, to provide a close fit which minimizes leakage of exhaled air around the edge of the mask.

The invention will be further explained with reference to the accompanying drawings, wherein:

Figure is a perspective view of a mask of the present invention;

Figure 2 is a cross-sectional view of the mask of Figure 1 taken along line 2—2; and

Figure 3 is a perspective view showing a mask of this invention in use.

Face mask 10 consists of a central, usually rectangular body portion 12 intended to cover the lower portion of the face of the user. The mask is further provided with ties 14 at the ends thereof for securing the mask over the face of the user. A pleat 16 may be formed in the body portion of the mask to permit unfolding or widening thereof to cover generally the nose, mouth, and chin of user. In the folded condition the mask is more compact for packaging, shipment and storage. Edge binding 18 may be conveniently used to hold the layers forming the body portion 12 of the mask together, as well as holding in place the ends of the pleat 16. The ties 14 may also be extensions of the edge binding 18, or may be separate fabric or elastic strips if desired. Stitching 20 is a preferred means of holding the edge binding and layers of the mask body portion in place. Heat sealing, adhesives or tapes may, for example, also be used.

As seen in Figure 2, the body portion 12 of the mask is preferably formed of three layers. The central layer 22 is a web of filtering fibers. Face contacting layer 24 is a thin, soft, flexible, self-sustaining, non-absorbent, highly porous film of used and coalesced non-woven, inert, thermoplastic, synthetic polymeric fibers. The face contacting side of layer 24 has a smooth feeling skin-like surface. The outer layer 26 of the mask may be formed from any porous fabric, woven or non-woven.

Filtering web 22 is formed from long, very fine synthetic organic fibers having an average diameter of 0.5 to 6 microns, the very best combination of filtering efficiency and breathability being obtainable with fibers having average diameters of 1 to 3 microns. Preferably these fibers are in the form of loosely held-together bundles or "ropes", because in this form the fibers are much more resistant to matting together or compaction into a dense paper-like form which would cause excessive resistance to air flow through the web. Alternatively, the individual tiny fibers can be mixed with larger polymeric fibers which serve to prevent undue compaction.

The tiny fibers of the filtering web 22 are preferably formed in accordance with the procedure described in Naval Research Laboratory Report No. 111437, dated April 15, 1954, entitled "Manufacture of Superfine Organic Fibers". This procedure involves extruding a fine stream of molten polymeric material into a stream of heated air which causes a breakdown or attenuation of the extruded material into tiny fibers. Preferred polymers for forming such fibers for face masks include polypropylene, polyethylene, polyesters, polyamides such for example as nylon, polycarbonates, polyphenylene oxide, and fluorinated polymers such as polytrifluorochloroethylene. Other non-absorbent, slippery feeling hydrophobic thermoplastic polymers may also be used. The fiber diameter rather than the composition appears important in providing filtering characteristics. The fibers preferably have a minimum length of 0.5 cm. to avoid loosening or breaking off of short fragile fiber fragments which could cause irritation to the wearer if inhaled. Fibers of this length also assist in forming a web which is sufficiently coherent to be handled. The fibers are generally found to be ravelled and intertwined sufficiently to provide a web which is sufficiently dimensionally stable. It has been found that loosely ravelled bundles or "ropes" of fiber can be obtained by collecting the fibers at a distance of 20 to 40 inches (about 50 to 100 cm.) from the nozzle orifice, whereas at closer collection points individual fibers by themselves tend to mat into a dense paper-like web resistant to air flow and thus unsuitable for use in face masks. Such fibers can, however, be maintained in a suitable degree of separation by mixing large diameter organic fibers therewith. These larger diameter fibers may be 10 to 30 microns in diameter, and when uniformly mixed in with the fine fibers serve to prevent packing into a too dense web. The ropes or bundles of tiny fibers similarly serve to prevent excessive packing of the fibers, and it is preferred to use such bundles rather than the larger diameter fibers to maintain the porosity or separation of the fibers in the filtering web, because the step of mixing in the large diameter fibers is thus avoided.

In order to provide the needed ease of breathability, the filtering web should preferably have a void volume of at least 87 percent. The ease of breathability can be correlated with the pressure drop which occurs when air is forced through the filtering portion of the web at a controlled rate. As a standard test for checking the suitability of webs for use in practicing the invention, a disc of the filtering material 3 1/16 in diameter is used, and air is pumped through the material at a flow rate of 1 cubic ft. per

minute. The difference in air pressure between one side of the filtered disc and the other is measured with a manometer in a conventional manner. The pressure drop (measured in inches of water) should be in the range of about 0.25 to 0.85 inches H_2O (6.35 to 21.6 mm H_2O). Filters causing a pressure drop under these conditions of less than 0.25 (6.35 mm H_2O) are found to have poor filtering efficiency, while those causing a pressure drop of over 0.85 (21.6 mm H_2O) are unacceptable because of difficulty in breathing through a mask formed therefrom. Optimum results were obtained using webs which caused a pressure drop of 0.35 to 0.5 inches H_2O (8.9 to 12.7 mm H_2O).

The characteristics of the mask are also affected by the thickness or density of the filtering material. The acceptable range of filtering materials has been found to be 25 to 65 lbs. per 320 square yard ream of material (42 to 100 grams per square meter), with optimum range being 45 to 55 lbs. per 320 square yards (76 to 93 grams per square meter). Filters having a density of less than 25 lbs. per 320 square yards (42 grams per square meter) generally have poor filtering efficiency, whereas those having more than 65 lbs. per 320 square yards (110 grams per square meter) are undesirable because of difficulty in breathing and warmth caused by breathing through the mask.

Preferably, the exposed surface of the face contacting web has thermoplastic fibers fused together at their points of contact with each other and coalesced while retaining their fibrous form, thus forming numerous irregularly shaped tiny openings in said exposed surface to permit easy breathing therethrough. The face contacting layer can be constructed by forming a non-woven layer of randomly oriented thermoplastic fibers, and subjecting the matter to a heat treatment (e.g. 300°F. (149°C.) in the case of the polypropylene) sufficient to soften the fibers and cause them to adhere to one another to form a self-sustaining web. This web is then further treated to form a smooth surface free of fuzz or other irregularities by pressing it against smooth heated surface, for example, that of a heated drum or roller. Back-up pressure rollers or similar means can be used to insure that the matting is uniformly pressed against the surface of the drum. The temperature of the heated smooth surface should be sufficient to cause melting of the surface fibers of the matting, and sufficient flow to form a smooth flat surface without losing their fibrous form. The fused fibers are then coalesced in this smooth condition. In the case of polypropylene, a temperature of 330°F. (166°C.) is suitable. Other smooth heated surfaces, for example traveling belts, can be used instead of the heated drum. This treatment of the matting produces a surface having a smooth fuzz-free feel, while yet maintaining the porous nature of the layer. The layer may have an average of 10 to 40 holes per square millimeter of surface, and the holes preferably have an average area of less than 0.1 square millimeter, and constitute 10 to 40 percent of the total area of surface, and more preferably 20 to 30% thereof. The large number of tiny irregularly shaped holes permits easy flow of air through the layer and thus provides for easy breathability while forming a containing envelope for the filtering web which prevents inhalation of loose fibers or irritation due to skin contact with the filtering layer. The thermoplastic fibers from which the layer is formed should preferably be no greater than 4 denier and more preferably are 3 denier fibers, and the resultant face-contacting layer may have a weight of 3.1 to 12.9 grains per 24 square inches (0.0013—.0054 grams per square centimeter), and preferably from 4 to 6 grains per 24 square inches (.0016 to .0025 grams per square centimeter). The absence of adhesives or binder resins in the web avoids odors normally found in webs bonded by the use of such means.

The invention will be further explained with reference to the following example in which all parts are given by weight, unless otherwise indicated.

Example

A filtering web made up of bundles of polypropylene fibers of the required dimensions was formed as follows. A polypropylene resin having a melting point of 333° F. (168° C.) was extruded through an orifice having a diameter of 0.020 inch. The extruder was operated at a temperature of 700° F. (371° C.), the extrusion die temperature being 560° F. (293° C.). The extruder was operated at a rate of 14 lbs. (6.35 kg) of resin per hour. The resin emerging from the die was imediately blasted with hot air at 800° F. (427° C.), which was discharged from a 3/4 inch (1.9 cm.) opening at a pressure of 5 psi (.34 atmospheres). The web was collected at a rate of 21 ft. per minute (6.4 meters per minute) at a distance of 38 inches from the extrusion die. The fibrous web thus collected consisted of loosely ravelled bundles or "ropes", of tiny individual fibers having diameters of 0.5 to 3 microns, and an average diameter of 1.5 microns.

A face contacting web was also formed from polypropylene. Three denier polypropylene staple fibers were formed into a non-woven matting, using conventional apparatus. The matting has a weight of 5 to 7 grams per 24 square inches (.0021 to .003 grams per square meter). The matting was passed over a smooth surfaced heated drum having a surface temperature 330° F. (166° C.) using a pressure roller to compact the

matting to insure uniform heat transfer to the surface of the matting. The fibers nearest the surface of the drum melted, but retained their fibrous form. On coalescing, a smooth non-fuzzy surface having a human-skinlike appearance with a myriad of tiny pores or holes therethrough was formed.

An outside cover web for the mask was formed from rayon fibers. 1.5 denier viscose rayon fibers were processed on a garnet machine (i.e. fiber orienting machine) which formed a fluffy non-woven web having fibers substantially aligned in the direction the web traveled. The following binding solution was applied by means of a compacting wool roller to bind the rayon web into a relatively tear-resistant form:

	Parts
Polyvinyl alcohol (Shawanigan Gelvatol 20—60)	50
Water	600
Blue pigment	0.44
Green pigment	0.26
Urea-formaldehyde resin	10
$Al_2(SO_4)_3$	2

The urea-formaldehyde resin and the $Al_2(SO_4)_3$ serve to insolubilize the polyvinyl alcohol resin, providing a fuzz-free surface, and also bind the pigments to the web, preventing color bleeding. Upon drying, the web had no perceptible odor.

Rectangular pieces of the three webs were assembled with the filtering web sandwiched between the facing webs. Strips of the rayon cover web were folded over to form narrow strips 1.6 cm in width. These strips were then folded around the edges of the assembled webs and stitched into place as shown in the drawings. The edge binding was extended 15 inches (38 cm) beyond each side of the top and bottom edges of the mask body to provide tie strings. A 3/16th inch (0.48 cm) wide double layer of aluminium foil backed pressure sensitive adhesive tape 6 inches (15 cm) long was enclosed in the binding along the major portion of one edge to form a deformable nose band which will retain the shape of the user's face contour to minimize air leakage.

The masks, when worn with the polypropylene facing web against the wearer's face, were comfortable, provided ease of breathability, and did not interfere with normal conversation. The masks were tested for efficiency on a capped masked human subject, in accordance with the Greene-Vesley in vivo method described in the Journal of Bacteriology, Vol. 83, No. 3, March 1962, pp. 663—667. The subject's head was placed in an enclosed chamber and any expelled moisture droplets collected on agar-agar. The masks each had an efficiency of 97.7% as defined by this in vivo test method.

WHAT WE CLAIM IS:—

1. A face mask having a body portion adapted to cover the nose and mouth and means for securing said body portion of the nose and mouth, the body portion comprising:

a face contacting web comprising a non-woven, porous, self-sustaining, flexible, fibrous matting having an exposed smooth, fuzz-free surface, and

a porous, non-woven filtering web consisting substantially of thermoplastic organic fibers, said fibers being uniformly distributed through said filtering web and having diameters averaging less than 6 microns.

2. A mask according to Claim 1 wherein the thermoplastic organic fibers are polypropylene fibers.

3. A mask according to Claim 1 or Claim 2 wherein the thermoplastic organic fibers have an average diameter of from 0.5 to 6 microns.

4. A mask according to any one of the preceding claims wherein the thermoplastic organic fibers have an average diameter of from 1—3 microns and a length of at least 1/2 centimeter.

5. A mask according to any one of the preceding claims wherein the exposed surface of the face contacting web has an average of 10 to 40 holes per square millimeter of surface, said holes having an average area of less than 0.1 square millimeter and constituting 10 to 40% of the area of said surface.

6. A mask according to any one of the preceding claims wherein the exposed surface of the face contacting web has thermoplastic fibers fused together at their points of contact with each other and coalesced while retaining their fibrous form, thus forming numerous irregularly shaped tiny openings in said exposed surface to permit easy breathing therethrough.

7. A mask according to any one of the preceding claims wherein the void volume of the filtering web is at least 87% and the pressure drop caused by said filtering web is from 0.25 to 0.85 inches H_2O when air is pumped through a 3—1/16th diameter disc of said filtering web at a flow rate of 1 cubic foot per minute.

8. A mask according to Claim 7 wherein said pressure-drop is from 0.35 to 0.5 inches H_2O.

9. A mask according to Claim 7 wherein said filtering web has a weight per unit area of 25 to 65 pounds per 320 square yard ream.

10. A face mask according to any one of the preceding claims in which the thermoplastic organic fibers are in the form of loosely ravelled bundles.

11. A face mask according to any one of the preceding claims including a retaining fabric layer comprising a non-woven fibrous web, the filtering web being contained between the

surface opposite the exposed surface of said face contacting web and one surface of said retaining fabric layer.

12. A face mask according to Claim 1 substantially as herein described with reference to the accompanying drawings.

For the Applicant:
LLOYD WISE, BOULY & HAIG,
Chartered Patent Agents,
Norman House,
105—109, Strand,
London W.C.2.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1217892 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

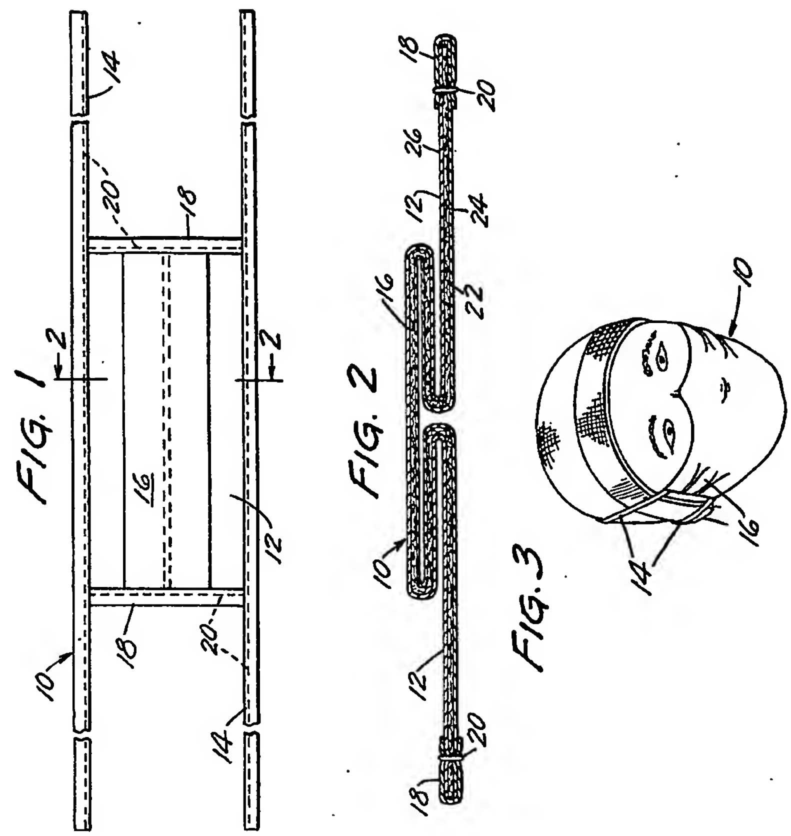

FIG. 1

FIG. 2

FIG. 3

THIS PAGE BLANK (USPTO)